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SUMMARY OF ARPA-ASO, TTO AERIAL PLATFORM PROGRAMS: VOLUME II, REMOTELY PILOTED HELICOPTERS

(Report No. A-4642-II, Task No. 44)

by

F. A. Tietzel, M. R. VanderLind, and J. H. Brown, Jr.

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NITE PANTHER	Sensor systems	Balloon Transport System
Aerial platform	Family II	EGYPTIAN GOOSE
Tethered balloon	BJ+3	Balloon fabric

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This report discusses the various aspects of the ARPA Advanced Sensors Office unmanned aerial platform work in support of sensor systems and sensor/weapon systems applicable to the Southeast Asia (SEA) conflict; Volume I focuses on balloons, and Volume II addresses remotely piloted helicopters.

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FOREWORD

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DISCLAIMER

The views and conclusions contained in this report are those of the authors and should not necessarily be interpreted as representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency or the U. S. Government.

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EXECUTIVE SUMMARY

This report discusses the various aspects of the ARPA Advanced Sensors Office unmanned aerial platform work in support of sensor systems and sensor/weapon systems applicable to the Southeast Asia (SEA) conflict; Volume I focuses on balloons, and Volume II addresses remotely piloted helicopters. The material presented covers the period from late 1967 to the present.

ARPA was interested primarily in timely military systems applications of their advanced sensors. In order to deploy these sensors, suitable aerial platforms were needed. Thus, efforts were made to devise baseline systems using existing balloons and remotely controlled helicopters. When the ARPA balloon program identified that there was a lack of sufficient technology to support the rapid development of a ruggedized military stable platform balloon system, programs were subsequently initiated to achieve such a balloon system. Many balloon-related technologies were addressed prior to and concurrently with the development of an entirely new 200,000-ft^3 balloon system. This system, developed, tested, and evaluated by ARPA, is undergoing some sensor system improvements/refinements under a follow-on Air Force effort.

The significant results of the remotely controlled drone helicopter program supporting NITE GAZELLE and NITE PANTHER are summarized. The modified QH-50D helicopter proved to be a suitable platform for real-time remote surveillance operations over enemy territory and, when armed with various armament systems, it was demonstrated to be suitable in a hunter/killer role.

SUMMARY OF ARPA-ASO, TTO AERIAL PLATFORM PROGRAMS: VOLUME II, REMOTELY PILOTED HELICOPTERS

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INTRODUCTION

The tactical military use of VHF/UHF FM communication systems and wide-band data links for advanced sensors frequently can be improved by the use of an aerial platform or airborne relay. These systems are principally line-of-sight (LOS) and are limited in range by natural obstacles, the curvature of the earth, and irregular terrain. A suitable unmanned aerial platform which is easy to launch and recover could eliminate the frequently used, more costly airborne relay. Tethered balloons and remotely piloted helicopters are easier to launch and recover than conventional drone/remotely piloted airplanes. This report discusses the various aspects of the ARPA Advanced Sensors Office unmanned aerial platform work in support of sensor systems and sensor/weapon systems applicable to the Southeast Asia (SEA) conflict; Volume I focuses on balloons, and Volume II addresses remotely piloted helicopters.

Defense Problem Addressed

The military operations in Southeast Asia (SEA) presented many new and challenging problems to all those concerned with the conflict, from the field units all the way up through the system planner and concept originator supporting the Department of Defense (DoD). The environment, terrain, weather, state of development, and mode of operation made the use of standard weapons and tactics rather ineffective in many cases. ARPA, in order to have closer liaison in the field and to implement applications of new technological developments, established a field unit identified as ARPA-Research and Development Field Unit-Vietnam, ARPA-RDFU-V. This unit made it possible to react rapidly to certain front-line military needs. It also provided rapid feedback of data from test and evaluation (T&E) efforts and was close enough to be effective as a direct monitor of some T&E activities.

The ARPA mission is essentially R&D oriented; however, sometimes it is necessary to obtain military operational T&E data on system components using immediately available equipment in order to quickly identify the deficiencies in such components. ARPA-ASO was interested primarily in timely military systems applications of their advanced sensors. In order to deploy these sensors, suitable aerial platforms were needed. Thus, efforts were made to devise baseline systems using existing remotely controlled helicopters.

The Southeast Asia (SEA) military theater quickly revealed that this type of military engagement was unprecedented. Existing equipment (or the available equipment) often was ineffective when the following demands and constraints were confronted:

- Longer than normal patrol activities
- Patrol activities in a dense jungle environment
- Hit and run tactics of the enemy, making the enemy difficult to locate for counteraction
- Artillery emplacements scattered and well hidden in the jungle environment, making counteraction difficult
- Frequent lack of enemy recognition of agreements governing the designated DMZ (demilitarized zone). (The enemy used this area as a launch area for fire power against their opposing units.)

The last situation prompted the initiation of Project BLOW HOLE in September 1967. The aim of this project was to find a solution to the DMZ artillery problem that could be implemented in Vietnam in 45 days. ARPA's mission was to monitor and provide technical assistance to the Air Force on this quick-reaction effort(1). The ARPA-ASO NITE GAZELLE program, established in January 1968, was an offshoot of BLOW HOLE.

One of the ways it was believed that the material deficiencies experienced as a result of these five unique military situations could be reduced or eliminated was by the use of a remotely controlled aerial platform with search or search and kill capability. The ARPA-ASO program addressed this conceptual system by modifying the QH-50D remotely controlled helicopter

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(1) References at end of text.

with appropriate sensors or sensors and weapon systems. The QH-50D system also used a balloon-borne relay for long range command and control.

State of Tec.nology at Program Inception

Remotely piloted aerial platforms having sufficient payload capability, range, endurance, maneuverability and acceptable launch and recovery characteristics for ARPA-ASO's needs (BLOW HOLE Concept) were nonexistent except for the Navy's QH-50D ASW helicopter. Independent studies by the Institute for Defense Analyses and the U. S. Army named the QH-50 drone as the most appropriate vehicle for this mission.[(2)] A survey of other available helicopters revealed the QH-50 to be the only operational drone helicopter in the U. S. inventory.

The QH-50D Navy DASH helicopter was designed for short range (30 to 40 nmi)[(3)] delivery of antisubmarine weapons from U. S. Navy destroyers. Its origin goes back to the QH-50A, which was developed under a Navy contract issued 31 December 1958. The first remotely controlled flight of the QH-50A was made on 12 August 1960. Subsequent changes and modifications resulted in the QH-50B, C and D. The QH-50B first flew on 30 September 1960. The remotely controlled QH-50C first flew on 25 January 1962 and the QH-50D first flew on 9 April 1965. A total of 373 QH-50D's were ordered and delivered to the U. S. Navy[(4)].

The QH-50D vehicle used late 1950 to early 1960 technology and was as austere as possible. The original Navy design concept was that the vehicle might be lost to its own weapon upon delivery[(3)]. The vehicle was limited to line-of-sight (LOS) operation and an altitude of zero to approximately 1000 ft by the command and control system. Maximum useful flight radius was approximately 35 nmi and average endurance as 1 hr 45 min (with two Mk 44 torpedoes)[(5)].

Implementation of the original QH-50D design concept (expendable) yielded a vehicle which quickly received a bad reputation with respect to reliability. However, an examination of the records shows varying results, depending on application and user. Most losses were unexplained because insufficient data were recovered. However, since the original Navy concept envisioned the drone as a cheap, expendable vehicle, a mean time between

losses (MTBL) of 8 hr was deemed acceptable. In February 1968, after the QH-50 vehicle had reached full opertional status, and routine fleet exercises had vehicle utilization up, the operational loss rate was 8 vehicles per month (MTBL of about 60 hr).[3] However, other vehicle operations, specifically Atlantic and Pacific Fleet training and Gyrodyne development and production tests, had an MTBL of 250 hr, 176 hr, and 235 hr, respectively, for the QH-50 C/D vehicles of the period February 1962 through April 1969[4]. A much higher MTBL can be documented for the QH-50D series alone since it did not experience much development testing relative to the predecessor versions.

More than six ARPA-ASO programs used modified QH-50D remotely controlled helicopters, as it met their requirements and was the only readily available remotely controlled helicopter in the U. S. inventory. Its payload capability was in the right range but mission time was slightly low. Mission time could be extended by sacrificing some payload capability. Reliability needed to be investigated further, as the available data showed a wide spread and many of the losses had been reported as "cause undetermined". The configuration of the QH-50D was such that it adapted well to an assortment of mounts for sensors and sensor/weapon systems. Taking everything into account, the basic QH-50D vehicle was well suited to ARPA-ASO needs. With minimum modification it was able to perform as required. These modifications were all within the existing state of the art. Table 1 lists the major ARPA-related modifications to the basic QH-50D DASH helicopter and the additional flight tests conducted to verify the expanded operational flight envelope.

Specific Technical Problems Addressed by the ARPA Program

The remotely controlled helicopter effort was one of modifying the existing QH-50D Gyrodyne helicopter to two basic configurations and then integrating the appropriate sensors or sensor/weapon systems to provide a vehicle with a specific search or search and kill capability. In order to make the helicopter suitable for its new missions, the basic vehicle had to be improved in several areas such as reliability, operating radius, ease of control, etc.

TABLE 1. MODIFICATIONS TO QH-50D DASH HELICOPTER

DASH Equipment Removed

Main fuel system

Armament provision

Emergency flotation

Ballast (simulation of trainer telemetry)

Modifications to Basic QH-50D DASH

Original Modifications

- New main fuel system (self-sealing)
- Addition of two extended-range self-sealing fuel tanks
- Addition of armor plate, engine, and avionics system components
- Telemetry (SUP-TEL) with DAME capability
- "X" and "C" band radar transponders and antennas
- Extended range altitude system
- Revised altitude reference and readout system
- Turn coordination disabling system (permit flat turns)
- Lateral trim capability
- Collective limiting system

Modification Improvements

- Replaced (SUP-TEL) 14 parameter telemetry with (OP-TEL) 38 parameter telemetry
- Modifications resulting from the Reliability Program are discussed later under "Scientific and Technical Results"

Flight Tests Conducted for Flight Envelope Verification

- Flight tests with extended-range fuel tanks were conducted at Patuxent River Naval Air Test Center during the period 1 December 1968 to 31 March 1969.

ARPA-ASO initiated efforts to study the feasibility of developing a sensor/weapon system for the remotely controlled helicopter, QH-50D. This effort was in response to needs identified on 25 September 1967 by the Commander, U. S. Marine Corps Vietnam, with respect to the DMZ artillery problem. The Navy was already using modified QH-50D's called "SNOOPY" to provide standoff TV coverage for Navy guns, and NADC, Johnsville, was currently modifying four DASH units with LLLTV systems for tests in Vietnam[(6)].

It appears from the available data* that Project BLOW HOLE was started 28 September 1967, when ARPA had an initial meeting with the Air Force on the subject, "Quick Reaction on DMZ Gun Problem". This initial meeting had ARPA monitoring and providing technical assistance to the Air Force in finding a solution that could be implemented in Vietnam in 45 days[(1)]. Project BLOW HOLE continued to be identified as an ARPA-ASO program, but the scope of the program is somewhat clouded, as various reports state different definitions for the program. It is identified with the concept of using a remotely controlled helicopter equipped with remote sensors and a weapon system capable of attacking gun positions within the DMZ. This concept of using a drone vehicle to hunt and kill high-priority targets in Vietnam became the foundation of the NITE GAZELLE Program established by ARPA-ASO in January 1968[(7)]. The NITE GAZELLE Program was to develop an accurate sensing system and weapon delivery capability for the Navy DASH helicopter. BLOW HOLE continued as the development of an appropriate missile attack system for attack-on-ground targets. Later this became identified as LARS (Laser Aided Rocket Systems).

Shortly after the NITE GAZELLE program was implemented, ARPA-ASO established the NITE PANTHER program in response to an urgent request from MACV for assistance in providing real-time battlefield reconnaissance to the Marines of Khe Sauh[(8)]. Some of the early NITE GAZELLE work was directly applicable to this 30-day QRC (quick reaction change) program.

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* Project BLOW HOLE was added later to the Title "Quick Reaction on DMZ Gun Problem" - Memorandum for the Director, DDR&E, 28 September 1967, Sgn. RCS[(1)].

The QRC NITE PANTHER Program tested the ability of the DoD military complex to react smoothly and quickly in fielding new equipment to effectively meet a battlefield need. The equipment concept was proven feasible, and development work continued to improve various components of the total system as well to expand the types of sensors and weapons available to make up the various conceived systems.

The following remotely controlled helicopter scientific technical problems were addressed during the QRC NITE PANTHER and NITE GAZELLE programs:

- Isolate vehicle vibration from TV sensor system
- Increase fuel capacity for increased duration
- Provide some order of protection from hostile ground fire
- Improve controlability of aerial platform
- Provide vehicle condition status to remote operator
- Improve total system reliability[9]
- Expand operational envelope and maneuverability
- Develop precise sensor/weapon system mount
- Improve sensor/weapon system tracking ability
- Increase vehicle lift capability
- Improve navigational capability.

All these items were addressed during the NITE GAZELLE/NITE PANTHER programs from January 1968 through 2 February 1972. Most were accomplished to the satisfaction of the sensor/weapon system requirements under evaluation. The effort to increase vehicle lift capability was delayed for a period after the loss of the first test vehicle with the new 24-ft rotor system on 23 June 1970. The investigation identified some design deficiencies. Gyrodyne proposed (8 September and 1 October 1970) a redesign of some components, material changes, construction of five new blades, and testing.

Other Considerations Affecting the Program

The activities of the United States in Vietnam had a profound impact on the ARPA program. The military operations in Vietnam frequently paced the ARPA-ASO aerial platform activities. This pacing pressure was felt from three sources, DoD/DDR&E-directed tasks to support the military, QRC response

to specific requests from the field, and an internal eagerness within ARPA to prove that a concept or a system had a high potential of showing a good military payoff. Everything considered, the needs and pace of the Vietnam conflict probably did much to move advanced sensor technology into realistic applications of total sensor systems and sensor/weapons systems. Without the urgent needs of the military in Vietnam, the R&D weapon activities associated with NITE GAZELLE might not have been sponsored. While the program extended beyond the conflict, the basic identification of need came out of the emergency situation.

The ARPA organization and operating procedures were also changed or adjusted to serve the military in the field and to provide the ARPA program manager with timely first-hand information concerning technical service-related problems. An ARPA Research and Development Field Unit was set up in Vietnam (ARPA-RDFU-V) to determine ARPA-related military needs, to coordinate the deployment of prototype systems for Test and Evaluation (T&E) in the field, and to monitor and report on the various ARPA-related activities. Some operating procedures were streamlined to provide quick reaction funding for equipment and to direct communication channels with the pertinent parties. At the suggestion of Dr. Foster, DDR&E, a limited amount of funds ($2 to 3 million per year) was set aside for quick reaction contracts to fulfill SEA military RDT&E requests. Programs initiated to fulfill urgent needs of the military in SEA were frequently funded from this special fund, referred to as ZAP channel funds. The ARPA program management office had an assigned military officer to coordinate and expedite ZAP-channel-funded efforts with the appropriate service organization. This special handling between ARPA and the various service organizations and the recognized urgency of ZAP-channel-funded effort contributed greatly to program activation. DDR&E had a group identified as SEA Matters that was keenly aware of special problems and needs of the military in Vietnam. This group worked closely with ARPA to get special programs initiated and to identify urgent military needs to ARPA.

THE PROGRAM

Modified QH-50D Program Objectives

The program objective was to modify the basic Navy "DASH" QH-50D to make it a viable platform for standoff reconnaissance and surveillance, and for standoff search and kill operations. To accomplish this the modified QH-50D would need:

- Increased range
- Some protection from hostile firepower
- Increased maneuverability
- A mount system for sensor and sensor/weapon systems
- More accurate vehicle position data
- Added vehicle-to-target range data
- A means of isolating the sensor and sensor/weapon systems from the normal vehicle vibration.

These were accomplished in logical sequence to support the various sensor and sensor/weapon system needs. The deployment of the SEA NITE PANTHER vehicles early in the program identified the need for the following additional modifications:

- Provide the controller with additional vehicle status data
- Determine system failure modes and modify to improve reliability.

The original objectives and modifications were aimed at the goal of developing and evaluating a standoff hunter and standoff hunter/killer capability for the military. The modified QH-50D would be the remotely controlled aerial platform for the following ARPA-ASO sensor and sensor/weapon systems:

- Day and night TV with real-time data link
- Airborne Moving Target Indicator, MTI, radar with real-time data link
- Laser designator and laser aided rocket.

As the program developed, the following weapons were added to the assortment:

- Bomber dispenser
- 40-mm grenade launcher
- Hypervelocity gun (50 cal/w sabot and flechette).

The last addition to the NITE GAZELLE/NITE PANTHER Program was the development and testing of an electro-optical system identified as Project "BLOW LOW".

Program Organization

The ARPA-ASO Aerial Platform Program consisted of R&D and T&E efforts on two basically different platforms; aerodynamically shaped balloons and a remotely controlled coaxial helicopter. All the helicopter platform work was done under a number of subprograms belonging to the large NITE GAZELLE/NITE PANTHER Program. The balloon aerial platform effort consisted of numerous projects involving a number of different balloons, some of which were in support of a portion of the NITE GAZELLE Program. The balloons were procured with ARPA funds, while the remotely controlled helicopters were bailed from Navy inventories or new deliveries.

Contractors with strong backgrounds in various technical areas were under contract to evaluate and/or develop R&D components and systems and to act as systems integrators for components and subsystem payloads on the aerial platform. Table 2 identifies the various contractors, their program managers, and technical areas for the NITE GAZELLE/NITE PANTHER programs.

The modified QH-50D, used for the ARPA NITE PANTHER and NITE GAZELLE programs, was a modification to Navy-owned vehicles bailed to ARPA. Some of the vehicles were from existing Navy inventories, while others were fresh off the production line. Thus, it was natural to select the Naval Air Systems Command to act as ARPA's agent for modification and testing of the NITE PANTHER and NITE GAZELLE configured vehicles. All modifications and some initial tests were conducted at the Gyrodyne facility on Long Island. Close coordination of this activity was maintained by the resident Naval officer at the Gyrodyne plant. Additional tests were frequently conducted at the Naval Air Test Center, Patuxent River, Maryland, where the local Gyrodyne facility was used to support the effort.

TABLE 2. NITE GAZELLE/NITE PANTHER PROGRAM CONTRACTORS

Contractor	Product/Technical Area	Contractor's Managers
Gyrodyne Corp. of Amer. St. James, NY	Remotely controlled helicopter, rotor aircraft	Program: Peter Papadakos
Rockwell International - Columbus Aircraft Div. Columbus, OH	Two-axis mount aerial weapon systems Contrast tracker fire control system	Project Scientist: L. A. Stockum -
Martin Marietta Orlando, FL	Laser aided rocket system (LARS)	Program: James G. Houser
Sierra Research Corp. P. O. Box 222 Buffalo, NY 14225	Operational telemetry AN/SKR-1	-
International Engineering Co. Division of A-T-O, Inc. Arlington, VA 22209	Loran C/D equipment	Principal Investigator: J. A. Walsh Project Engineer: C. S. Mathews
Raytheon	Laser range finder	-

Technical direction of the NITE GAZELLE/NITE PANTHER Program was under an ARPA-ASO Program Manager supported by a Program Steering Committee, a NITE GAZELLE Weapons Committee, and a NITE GAZELLE Sensor Committee. These committees were made up of personnel from:

ARPA-Advanced Sensors Office
Hq. Naval Air Systems Command
Hq. U. S. Air Force
Hq. Air Force Systems Command
Chief of Naval Operations
Department of Army
Army Material Command
Aeronautical Systems Division (AFSC)
Defense Communications Planning Group.

Various major efforts within a project were sometimes managed by an ad hoc organization in order to more closely monitor and/or direct the effort. Typical multi-Service ad hoc management organizations that existed in connection with major efforts on the QH-50D helicopter are shown in Figures 1 through 3. The BLOW LOW program (electro-optical payloads) had relatively little impact on the platform and is not discussed in any depth in this report.

Formal reports on the ARPA-ASO efforts were kept at a minimum. The overall program was directed by memoranda, TWX's, and verbal communications. The aerial platform effort documentation was generally minimal and usually was incorporated as part of the sensor system or sensor/weapon system test report.

Motivation in the NITE GAZELLE/NITE PANTHER Program was strong and, in a sense, program induced from the start. The possibility of providing an effective remote surveillance and surveillance/weapons system quickly for use in Vietnam was very attractive. The success of the QRC NITE PANTHER Program, and the top level response* to this success, was excellent motivation for the NITE GAZELLE R&D effort.

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* Letter from Donald F. Hornig, Special Assistant to the President for Science and Technology, to Dr. John S. Foster, Director, OSD DDR&E dated 20 May 1968.

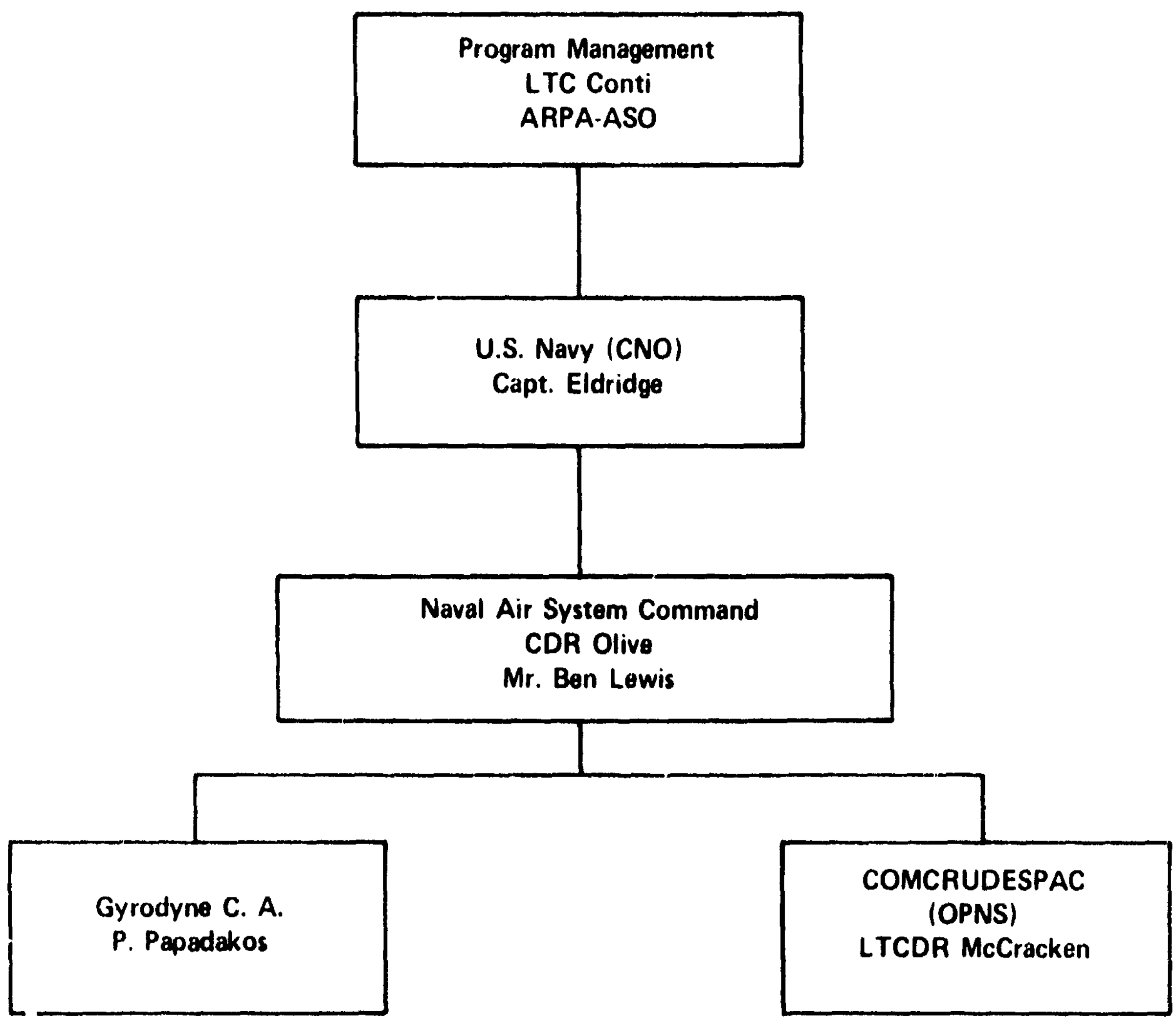

FIGURE 1. QH-50D RELIABILITY PROGRAM [10]

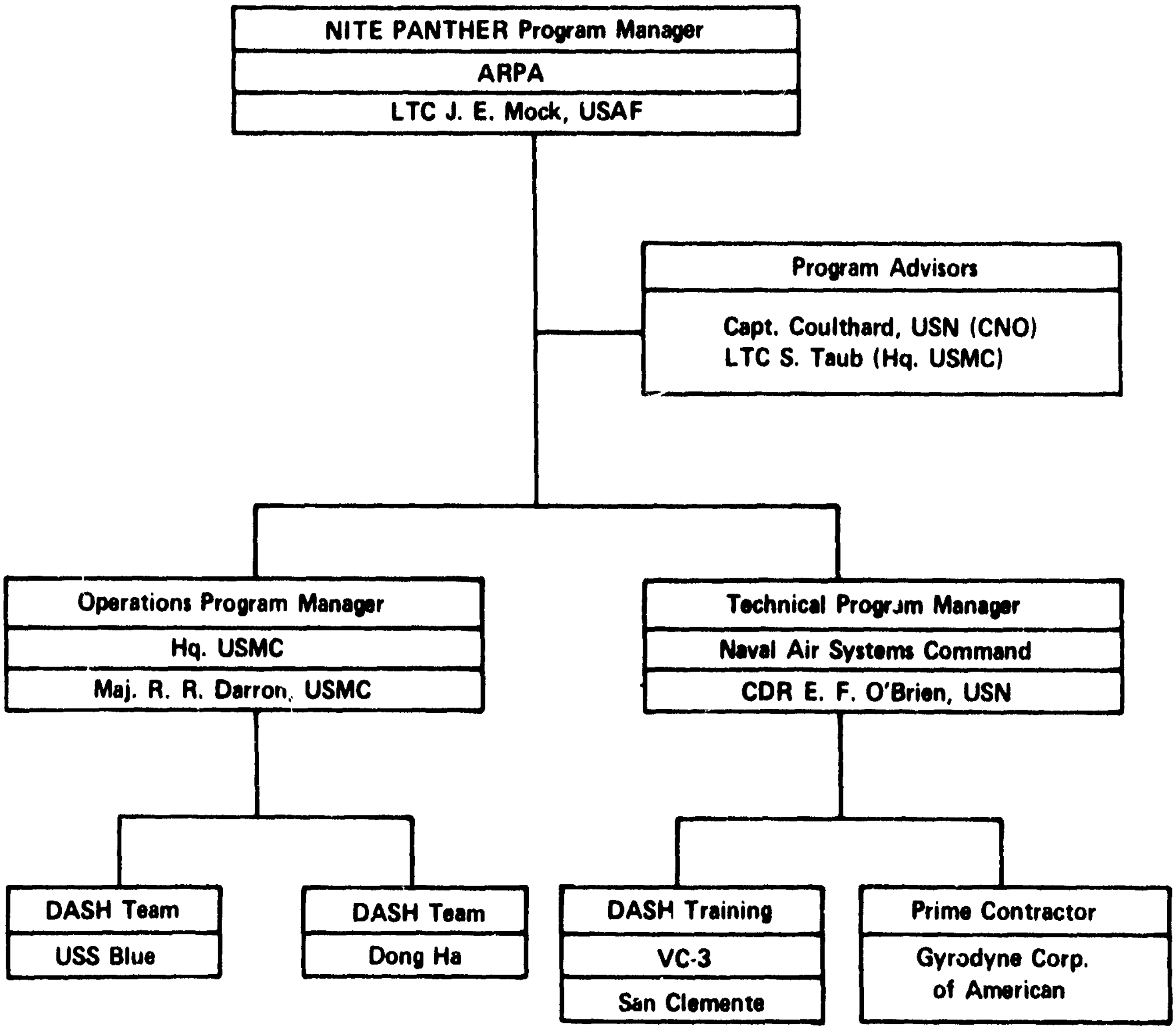

FIGURE 2. NITE PANTHER MANAGEMENT ORGANIZATION (11)

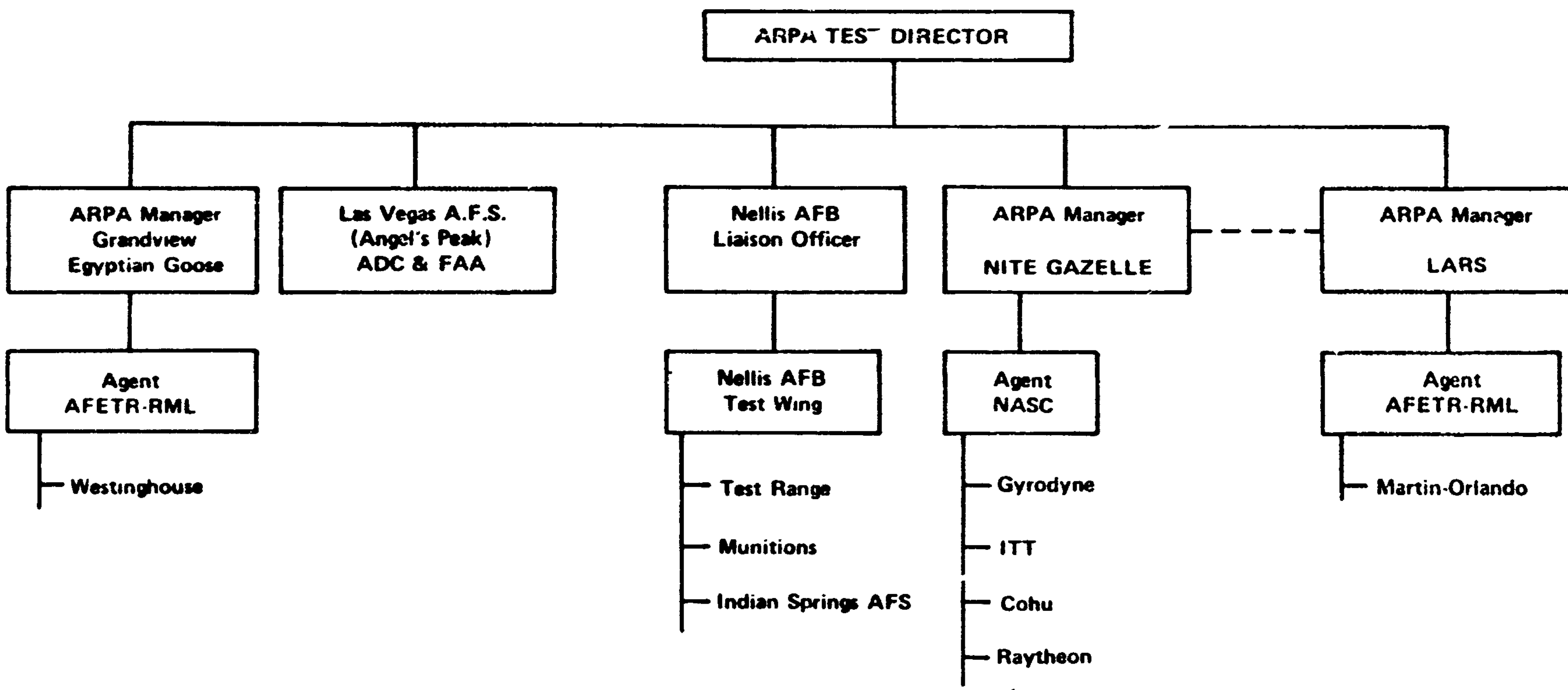

FIGURE 3. NIGHT GAZELLE -- NELLIS TEST ORGANIZATION[12]

Program Operation

The organizational arrangements generally were good for the aerial platform operations. The fast pace, lack of effective contingent planning, and an inadequate data base contributed greatly to increased costs and the need for longer testing periods. The one operation that probably generated additional problems, handicaps and delays in the QH-50D program was the extensive use of Nellis AFB, Nevada, as a test site. Nellis was not well equipped to support such a project, for it was not an R&D type of installation. A base like China Lake Naval Weapons Center may have been able to provide much better support. Some of the Nellis tests (system shakedown) may have been better conducted at locations closer to the manufacturer's plant.

SCIENTIFIC AND TECHNICAL RESULTS

The ARPA-ASO programs used two different modifications of the QH-50D helicopter. One configuration is identified as a NITE PANTHER vehicle and the other as a NITE GAZELLE vehicle. Design information on the modified QH-50D is presented in the Appendix, at the end of this report.

The QRC NITE PANTHER Program was aimed at providing quick-reaction, prototype, standoff battlefield surveillance systems for immediate operational use in Vietnam. The performance of this system in an operational environment was excellent. The final field report from the Marine project officer stated that "The NITE PANTHER Program proved that a helicopter drone is an excellent vehicle for real-time battlefield surveillance and target acquisition, and for controlling supporting arms fire." While scientific and technical data were not a goal of this program, the following platform-oriented gross technical data were obtained[11]:

(1) "It was demonstrated that the DASH helicopter is a sufficiently stable platform so that stabilized optics are not necessary under most flight conditions."

(2) "It was shown that the vehicle could be accurately positioned and navigated at all times using the information available from DME and TV systems."

(3) "--- a more reliable vehicle must be developed in order to provide a true operational capability."

The NITE GAZELLE Program used modified QH-50D remotely controlled helicopters as aerial platforms for a number of sensor and sensor/weapon systems. System flight tests were conducted during the period March 1968 to 2 February 1972 using the following sensors and sensor/weapon systems:

- Day TV camera
- LLLTV camera
- LLLTV camera with covert IR light
- Laser range finder
- MTI radar
- Electro-optical system
- Laser range finder/designator
- Bomblet dispenser
- Grenade launcher
- Mini-gun
- Hypervelocity gun
- Extended range with control through relay
- Laser aided rocket system.

While the flight test programs were conducted to evaluate sensors and sensor/weapons systems performance, these tests also produced some aerial platform-related data, such as:

- Measured noise levels
- Restricted flight regimes
- Stability data
- Effects of vehicle vibration
- Vehicle reliability data
- Vehicle/STW mount performance
- Vehicle-controller problems.

Early in the ARPA NITE GAZELLE/NITE PANTHER Program, a reliability program for the QH-50D helicopter was funded by the Navy. Prior to the NITE GAZELLE/NITE PANTHER Program, the Navy had attempted to fund such a program but was unsuccessful. The ARPA NITE GAZELLE interest and the results of the SEA NITE PANTHER Program provided the needed justification for a reliability test program. A four-vehicle, 1200-hr reliability test program was initiated

in August 1968. Shortly after the completion of this program, an MTI radar test vehicle was lost at the Gyrodyne plant facility. Investigation revealed that "purple plague" in the transistors of the electronic control amplifier (ECA) caused the loss of control and resultant crash. This revelation initiated an electronics retrofit program for all NITE GAZELLE/NITE PANTHER vehicles.

QH-50D Reliability Improvements

Significant improvements were made in platform reliability during the ARPA-ASO NITE PANTHER/NITE GAZELLE Program. Electronic subsystem reliability was improved by replacing commercial-type transistors with equivalent JAN-type transistors that were not subject to intermetallic formation commonly referred to as "purple plague"[13]. The use of the 38-parameter OP-TEL telemetry system on all vehicles except the QRC NITE PANTHER vehicles (Serials 1700, 1701, and 1702) greatly helped the controller diagnose conditions, take corrective action, and schedule better maintenance[9]. The addition of a fuel level readout[14] is a flight safety item; however, it can contribute to improving total system reliability.

The 1200-hr reliability program identified the need for reliability improvements in the flight control system, power train/propulsion system, command and control avionics, and payload subsystems. The specific improvements are listed below.

Flight Control System

- Turn coordination module modification in electronic control amplifier to lower rate of roll during turn entry and exit in cruise mode and increase range of bank angle adjustment.
- Modify electromechanical rotary actuator in order to eliminate oscillation in QH-50 control system when unlimited large down collective commands result in opening and closing of the limit switch.
- Incorporate the extended altitude range system without the direct collective alternate.

Power Train/Propulsion System

- Incorporate a collective up-stop to prevent controller from demanding excessive horsepower and modify rotary actuator clutch circuitry to eliminate oscillation in full-up position.

- Replace magnetic drain plug with electric chip detector (two locations) to monitor transmission condition in flight.

- Provide adapter for installation of transmission oil level indicator to allow for ease in checking oil level when auxiliary tanks are installed.

- Provide a fuel level indicator installation on the auxiliary tanks to permit selection of fuel loads for specific flight requirements.

- Install an acoustic continuous fuel sensing system for continuity of readout through the telemetry system.

- Install engine torque pressure transducer to provide continuous monitoring of engine power during operations.

- Incorporate new seals in (1) upper thrust bearing, (2) first stage pinion, and (3) generator drive.

Command and Control Avionics

- Incorporate RFI gaskets in the decoder, electronic control amplifier, and receiver.

- Incorporate solid-state relay for AN/SRW-4 command system control.

Controller Aids

- Provide means of mechanical "zeroing" for altitude telemetry, readout to give drone controller a means of reading directly the total vehicle altitude (prior system is set up for 600-ft altitude increments and the drone controller must remember how many increments up the vehicle is).

- Provide a telemetry indication of collective up-stop activation which tells the drone controller when he is at or close to full-up collective (at maximum collective with normal rpm and therefore needs higher engine rpm).

- Provide modification to the telemetry system to permit transmission of mount plan and tilt positions.

Controller Sensor Installations

- Provide waterproofing of the COHU and ITT camera control unit.

Initially, Navy records for the QH-50D vehicle showed a mean time between losses, MTBL, as 89 hr (from all causes, shipboard plus training operations)[3]. Later data (after reliability improvements) predicted MTBF as 226 hr[2]. This reliability improvement effort contributed greatly to the success of the ARPA-ASO sensor and weapon systems tests. Loss of any of these high-value, limited availability sensor and sensor/weapon systems would have greatly affected the total program.

Initial Weapons Test with NITE GAZELLE

The initial weapons tests of the 7.62-mm mini-gun and the Iron Bomb drops at Patuxent River NATC during February-March were unsuccessful. Consistent accuracy was found to be unattainable through the inertial system used. GCA proposed a "Walk-up Mode" modification in November 1969. This would permit the automatic positioning of the vehicle directly over the target for precise weapon/sensor delivery. The "Walk-up Mode" modification contract was initiated 6 February 1970.

Sensor and Sensor/Weapon Systems Mounts

A step-by-step improvement in sensor and sensor/weapon system mounts greatly contributed to the QH-50D's ability to perform its mission effectively. The first vehicles modified used a single-axis, bang-bang mount controlled in pitch only. The helicopter was commanded in yaw to provide a yawing of the sensor system. This was used on DS-1700, 1701 and 1702, QRC NITE PANTHER vehicles, DS-1682, the OLYMPIC vehicle, DS-1715 and 1721, SEEK LAUNCHER vehicles, and DS-1722 and 1726, the SEA DRAGON vehicles. The Air Force report covering the tests with the SEEK LAUNCHER vehicles[7] stated under "CONCLUSIONS ----Incorporation of two-axis proportional slewing mounts, continuous altitude control systems, and additional navigational control equipment be included in any operational design concept." The report also stated --- "A two-axis proportional mount must also supply the controller with

indicators which depict the angle of the mount and/or the area under surveillance in relation to the drone's position." The second mount was a two-axis bang-bang mount used on SILENT JOE II and NITE PANTHER II. SILENT JOE II was a powered balloon system using acoustic array and an LLLTV system with an IR light. The linkage between the TV mount and IR light was mechanical in the tilt mode and electrical in the pan mode. This arrangement was unsatisfactory. The same mount on NITE PANTHER II was interconnected to the IR light by an open-loop servo. The third mount was a two-axis, proportional position 1-deg mount initially demonstrated at GCA on 13 December 1968. The fourth mount (second Big "U" mount) was a two-axis, proportional rate gear-driven mount. The fifth mount (third Big "U" mount) was basically the fourth mount with antibacklash gear to provide 1-mil accuracy. The sixth and final mount (Fourth Big "U" mount) was a rework of the basic Gyrodyne Big "U" mount by Rockwell International, Columbus Aircraft Division. This mount used direct drive torques instead of the servomotor gear drive. The installation of the yaw torquer motor required the inverted "U" arms to be shortened and stiffened to provide adequate ground clearance and mount rigidity. The torquer driven mount achieved an inertial stabilization error of 0.034-milliradian peak ground test and 0.2-milliradian peak airborne[15]. This mount was checked out and factory balanced for the HV gun tests. At Nellis AFB there were problems with the gun, so it was removed from the mount and the mount was refitted with cameras and laser designator for LARS II testing. There were no facilities at Nellis to precisely align and balance the newly configured mount. However, mount and associated optical tracker performed well. The final two LARS II tests, Nos. 356 and 357, resulted in a direct hit on the laser spot held at the desired impact point on a stationary tank. One of these launches occurred at a target range of 6200 ft.

The reworked Big "U" mount was far from an optimum design; shortening and stiffening it produced a heavier than necessary mount, plus it required about 30 lb of balance weights for the LARS II configuration. A new mount of optimum design would result in a significant reduction in weight for the same performance. The weights associated with the reworked Big "U" mount are listed in Table 3. A large portion of the increased mount weight (plus approximately 230 lb) was due to the weight of the torquer motors (53 lb each)[16]. Table 4 gives an overview of the various surveillance, tracking and weapon (STW) mounts that were developed on the NITE GAZELLE/NITE PANTHER Program.

TABLE 3. WEIGHTS AND DIMENSIONS OF TORQUER DRIVEN BIG "U" MOUNT AND ACCESSORY EQUIPMENT[16]

Item	Weight, lb	Outside Dimensions (H x W x L), in.	Mounting Dimensions (W x L), in.
Fire control computer chassis	35.5	7-1/8 x 12 x 20	9 x 18-7/8
Battery pack	17.5	5-1/4 x 9-1/2 x 12	8-7/8 x 7-3/8
Turrent control breaker	2.5	6-1/8 x 5-3/8 x 3	4-5/8 x 2-1/4
Power amplifier	22.5	7-5/8 x 6 x 13	4-3/8 x 12-7/8
NR mount[a]	481	NA	NA

(a) The mount weight includes:

(1) Motion picture camera (16 lb)
(2) TV camera (9.5 lb)
(3) Two reticles
(4) 50-cal gun, gun cradle, and gas bottle
(5) Balance weights
(6) Cable harness.

The mount weight does not include the ILS laser, which is expected to weigh 15 to 25 lb.

TABLE 4. SURVEILLANCE, TRACKING, AND WEAPON (STW) MOUNT DEVELOPMENT(16,18)

Type of Mount	Control	Drive	Linkage for IR Light	Mount Weight, lb	Payload	Program Vehicles	Performance
Single axis (pitch only)	Bang-bang	Gear	—	19.3	Day TV camera	SEA NITE PANTHER/ DS-1700,1701,1702	Adequate
			Mechanical	25.8	LLLTV camera (covert light)	SEA NITE PANTHER/DS-1700, 1701,1702	Adequate
			—	DNL	Day TV camera	OLYMPIC's/DS-1682	Adequate
			DNL[a]	DNL	LLLTV camera (covert light)	OLYMPIC's/DS-1682	Adequate
			Mechanical	25.8	LLLTV camera (covert light)	SEEK LAUNCHER/ DS-1715,1722	Unsatisfactory, needs a two-axis proportional mount(9)
Two-axis	bang-bang	Gear	Mechanical tilt and electric pan	DNL	LLLTV camera (covert light)	SILENT JOE II	Unsatisfactory
			Open-loop servo	DNL	LLLTV camera (covert light)	NITE PANTHER II	DNL
Two-axis (Big "U")	Proportional position	Gear	Open-loop servo	DNL	DNL	DNL	Demonstrated at GCA 12-13-68(21) (no other information located)
Two-axis (Big "U")	Proportional rate	Gear	Open-loop servo	DNL	DNL	DNL	DNL
Two-axis (Big "U")	Proportional rate	Anti-backlash gear	DNL	DNL	DNL	DNL	DNL
Two-axis (modified Big "U")	Proportional rate	Direct drive torquer	None	DNL, see Table 8	Day TV camera, motion picture camera, ILS laser	NITE GAZELLE, LARS II/ DS-1715	Excellent

(a) DNL = data not located.

Higher Lift Modified QH-50D

ARPA-ASO initiated the development of a 24-ft rotor system for the modified QH-50D helicopter, the QH-50D-2. This vehicle, with its increased lift capability, offered markedly improved payload-range-endurance performance. The increase in rotor diameter would appear to have been a relatively minor development program[3]. The limited radius of action and target area dwell time of the 20-ft rotor vehicle emphasized the need for the 24-ft rotor vehicle. The 24-ft rotor vehicle was capable of 6-hr missions with any of the developed sensor/weapon systems[17].

QH-50D Audio and Radar Signature

The Navy design requirements and planned operational deployment of the QH-50 series of vehicles were such that neither audio nor radar signature was of concern, thus no measurements of these two parameters had ever been made. Audio and possibly radar signature could have an effect upon the utilization of the vehicle under the ARPA program and under a proposed AF usage. The signature data were taken by the AF Aeronautical Systems Division (ASD) on a series of flight tests at Patuxent River Naval Air Test Center and by the Armament Development and Test Center (ADTC) in a series of SEEK LAUNCHER Program tests conducted at Eglin AFB, Florida. Radar cross section was measured by Radiation Service Co., Melbourne, Florida, on an Army ECOM contract. These data are reported in References (7), (19), and (20). Table 5 identifies data available in each report.

TABLE 5. QH-50D SIGNATURE DATA

	Signature Data				
Source Document	Audio	Sound Pressure Level	Visual	IR	RCS at GHz
AF-ASD report[23]	✓	✓			
AF-ADTC report[9]	✓		✓		
ECOM report[24]	✓		✓	✓	3.0, 5.5 and 9.0 GHz

The following general signature assessment was stated in the various reports:

- Drone was heard at all altitudes up to 5,500 ft at slant ranges between 14,500 and 18,700 ft[7].
- Drone was visibly acquired at slant ranges of 1,420 to 2,900 ft when light was greater than half moon.[7]
- Drone was heard at slant ranges of 16,000 ft in the NATC environment. The estimated range for daytime jungle environment would be 34,000 ft[19].

Navigation/Tracking Aids for QH-50D

The existing system position data for the QH-50D vehicle were not accurate enough for some missions and the ability to return the vehicle to a previously occupied position needed to be improved. The feasibility of incorporating a system using Loran C to improve the accuracy of position data was investigated. A system was developed and tested using a Loran C sensor to feed raw Loran signals to the AKT-20 data link transmitter for retransmission to the QH-50D ground control station. These data retransmitted over the QH-50D multiplexed telemetry transmitter were received at the ground station, demultiplexed and fed into auxiliary equipment without degradation to the vehicle telemetry data or the Loran data. The auxiliary equipment consisted of a "NIGHT DIAL" computer/interface unit, an AN/ARN-92 Loran receiver, a map drive computer, and a "NIGHT DIAL" map plotting board. This system was flight tested at Patuxent River NATC in the summer of 1970. The evaluation of data revealed[21]:

(1) Accuracy of Loran C time difference coordinates referred to a chart system is approximately 600 ft.

(2) Within a particular area, chart reference accuracy can be improved to approximately 200 ft by use of a fixed Loran monitor to provide relative position data. This technique is valid over an area of at least 100 square miles.

(3) Return to a previously occupied position can be achieved to within 60 ft.

(4) Loran C signals are not degraded by retransmission using an FM link such as found on the QH-50D.

(5) Loran retransmission techniques can be used for remote positioning of a platform.

As a result of this successful R&D effort, six systems were acquired for the QH-50D vehicle and three ground stations were outfitted.

Contrast Tracker and Fire Control System

The manual control of the two-axis proportional mount through the TV data link would not provide the tracking and aiming accuracy needed for effective weapon kill. Thus, a high resolution optical contrast tracker and a flyable computer were developed for NITE GAZELLE to provide precise aiming and correctional signals to the fire control system for the hypervelocity gun. This fire control computer and contrast tracker (FCC/TKR) was developed by Rockwell International, Columbus Aircraft Division, applying techniques similar to those employed in the CONDOR air-to-surface missile and the E/O HOBOS air-to-surface homing bomb. The outputs of the tracker are used as input drive signals to the two-degree-of-freedom stabilized platform on the modified QH-50D. The flyable fire control computer provides the aimpoint system with aiming point adjustments to correct for projectile ballistics, helicopter and target velocities and crosswinds.

Gun and mount problems did not permit a good performance evaluation of the total system in operation. The accuracy of the FCC for typical flight conditions of 2,000 ft, pitch and pan rates of 0.5 deg/sec, and forward and lateral velocities of 20 ft/sec were experimentally measured as 0.1 milliradian error in both axes. The maximum tracking rate capability of the contrast tracker was measured with a mechanical simulator at 1 raster/sec in both the horizontal and vertical directions[22].

Summary of QH-50D Platform Effort

The modifications and flight testing of platforms, and platform with sensors or sensor/weapons systems were accomplished over a 4 to 5-year period. This effort is summarized in Figure 4, which gives a time-related overview of key platform results as well as the flight test activities associated with each sensor and sensor/weapon system test.

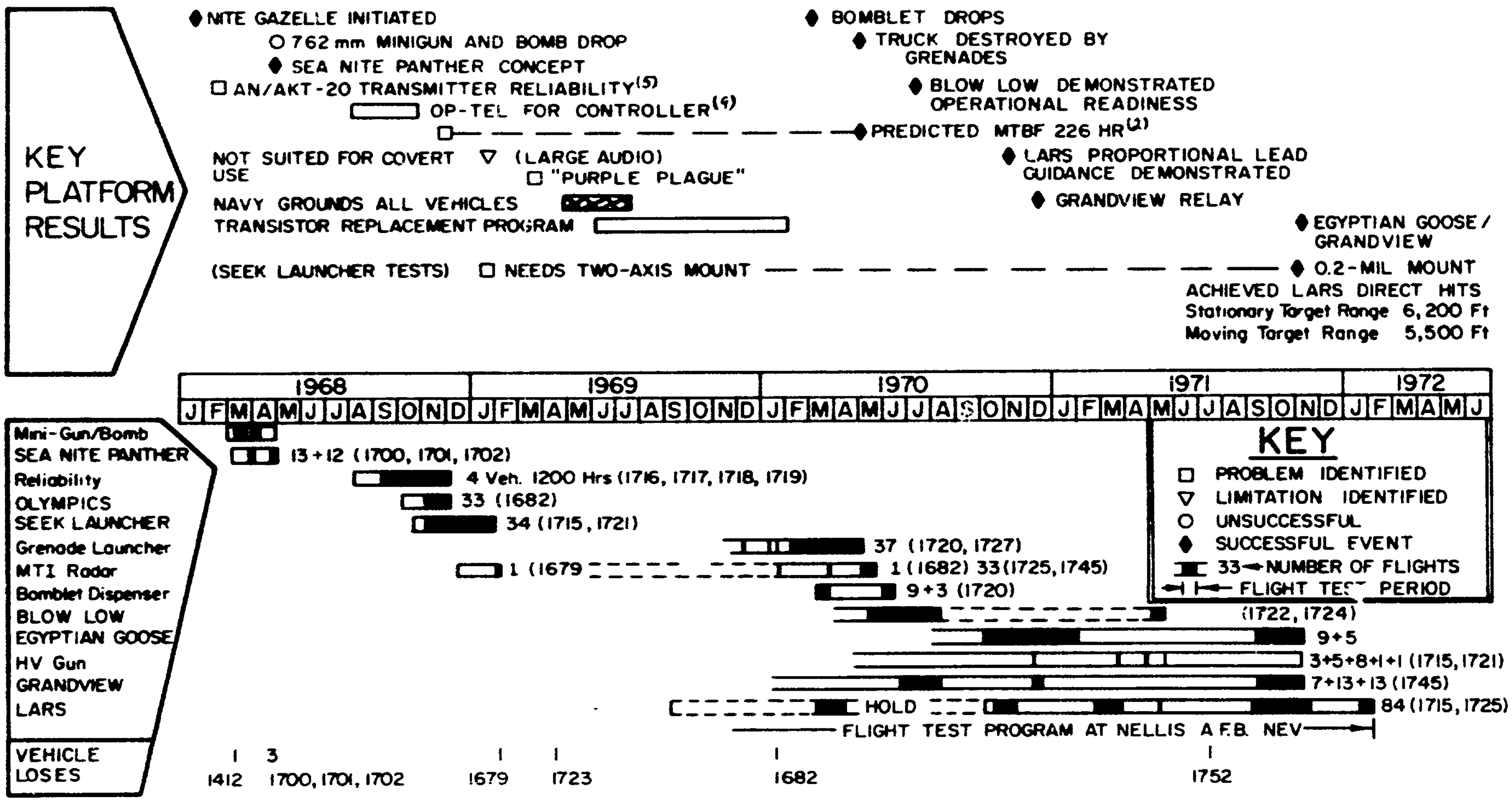

FIGURE 4. ARPA-ASO NITE GAZELLE/NITE PANTHER PROGRAM

CONSIDERATIONS FOR THE FUTURE

Further R&D Needs and Recommendations

The NITE GAZELLE/NITE PANTHER Program proved the feasibility of the basic concepts; however, the test phase was limited and high system performance was not always demonstrated. Table 6 identifies the various NITE GAZELLE tests that should be considered for any follow-on effort with this system.

Another capability that should be considered for any follow-on development of a NITE GAZELLE or similar vehicle carrying LARS is the capability of launching more than one missile per sortie. With the present system a missile failure means a totally nonproductive sortie.

A R&D effort related to the NITE GAZELLE/NITE PANTHER Program that was never adequately addressed is to find a way of guarding against the loss of a vehicle by power settling. This phenomenon is a characteristic of rotary wing aircraft in a hover mode with little or no wind. Since helicopters make ideal RPVs for front-line operations due to the ease of launch and recovery, their use will continue to be explored. The control of an RPV requires some additional cues to replace those normally experienced by an on-board pilot. A sensor system should be developed to detect initial stage of power settling in order to alert the remote pilot and perhaps even initiate an automatic program of corrective action. The payoff from this could be significant when considering that the loss of three NITE GAZELLE/NITE PANTHER vehicles (DS-1682 on 1-20-70; DS-1752 on 7-15-71; DS-1412 on 3-14-68) with high value sensors was attributed to power settling.

Assessment of Technological Feasibility

The technological feasibility of using remotely controlled helicopters for sensor and sensor/weapon systems platforms has been proven in all cases tested. The military need and acceptance of these various tested systems is very much in question. A standoff sensor and sensor/weapons system is feasible, (1) using a remotely controlled helicopter platform equipped to provide the military field commander with the capability to see and locate in

TABLE 6. RECOMMENDED FOLLOW-ON NITE GAZELLE PLATFORM PERFORMANCE TESTS

Sensor/Weapon	Vehicle Configuration, Two-Axis Mount (Proportional Rate): Modified Servomotor Gearhead	Vehicle Configuration, Two-Axis Mount (Proportional Rate): Direct Drive Torquer	More Tests Needed	Rework/Redesign Mount Interconnection/Control Problem with Two Units	Extend Depression Angle Capability of Mount	Develop Lighter Weight Torquer Driven Mount
MTI radar	OK	Not needed	TV/radar transfer control	Yes	No	No
LARS	No	Yes	Yes - with latest mount[(a)]	N/A	No	Yes
Hypervelocity gun	No	Yes	Yes - with latest mount[(b)]	Yes	No	Yes
Bomblet dispenser	OK	Not needed	If impact sighting needed	N/A	If needed	No
Grenade launcher	OK	Not needed	Night tests needed	N/A	No	No
GRANDVIEW	N/A	N/A	Two or more drones	N/A	N/A	N/A
EGYPTIAN GOOSE	N/A	N/A	Max. range and accuracy	N/A	N/A	N/A

(a) Only two tests were made with the torquer driven mount. Mount was not precisely balanced and adjusted for the two tests. Nellis AFB test data[(16)].

(b) Tests with hypervelocity gun on torquer driven mount incomplete. Trouble with gun performance during checkout; removed gun and installed LARS. Nellis AFB test data[(16)].

real time the enemy's order of battle as it is evolving, targets can be located, tracked, and attack with an onboard precision weapon to effect an efficient target kill. All this can be done without exposing the man to the hostile military environment, (2) using the remotely controlled helicopter platform with a balloon-borne relay and radar system, the standoff sensor and sensor/ weapon system can be operated out to a radius of 100 to 120 miles.

State of Technology at Close of NITE GAZELLE/PANTHER

ARPA's activities with the NITE GAZELLE/NITE PANTHER program ceased in June 1972. At that time the ARPA-supported program had accomplished the following:

- Battlefield demonstration of NITE PANTHER concept, real-time battlefield TV surveillance.
- R&D demonstration of the NITE GAZELLE concept with the following standoff interdiction weapon systems:

  (1) Laser Aided Rocket System, LARS
  (2) Hypervelocity gun (needs improved accuracy tests)
  (3) Bomblet dispenser
  (4) Grenade launcher.

- R&D demonstrations of extending the operating range of the NITE GAZELLE vehicle by use of:

  (1) Elevated relay, "GRANDVIEW"
  (2) Elevated MTI radar, "EGYPTIAN GOOSE".

R&D testing was minimal; although the concepts were demonstrated, additional testing is needed to refine and improve the performance of most of the ARPA tested systems. One weak point of the final concept demonstration is that the controllers of the modified QH-50D airborne platform were always Gyrodyne personnel with extensive experience. Military trained personnel with more limited experience may have difficulty in achieving the demonstrated vehicle/ sensor-weapon system performance.

Status of Related Activities

The Navy was the original user of the QH-50 vehicle. This vehicle was used with destroyer-class ships to provide a standoff capability of

delivering ASW torpedoes. It had been actively deployed, and phasing out had begun about the time ARPA initiated the NITE GAZELLE Program. This phaseout was the result of a more advanced ASW system. The Navy issued an RFP during the Spring of 1974 for a 500-lb RPV to be operated from shipboard.

It is known that the Army conducted follow-on activities with NITE GAZELLE vehicles (those transferred from the ARPA Program), but details of these activities are not readily available.

The EGYPTIAN GOOSE system and GRANDVIEW system are balloon-borne MTI radar and communication relay for extended range operation of NITE GAZELLE. These systems were originally planned for transfer to the Air Force with seven NITE GAZELLE systems; however, the Air Force rejected the transfer in May 1971[23] and the equipment was disbanded (some of it to storage).

Management Transfer of NITE GAZELLE/PANTHER

Standoff sensor systems, consisting of two BLOW-LOW vehicles, two MTI radar vehicles, and one spare RCV, were transferred to the Army on 11 December 1970. Seven modified QH-50D's were scheduled to be transferred to USAFSC/TAC, but the transfer was rejected (May 1971).

REFERENCES AND RESOURCES

Documentation

The Reference List at the end of this section and at the end of each of the Appendices provides source documents which substantiate the material contained in this report and may also contain a sizable amount of additional material. The documents referenced were mainly from the ARPA-ASO Program Office files. Much of the documentation is in the form of internal memoranda for the Director, for Program Management, and/or for the Record. These documents have all been placed in federal storage.

Additional information should also be available from personnel associated with the program; however, since a high percentage of the personnel were militar and government workers, their help will decrease rapidly with time.

Contractor engineering personnel can probably provide the most help, especially if they can retrieve data easily from company files.

Equipment Assets

The equipment assets at the close of the NITE GAZELLE/NITE PANTHER Program are listed below:

NITE GAZELLE vehicles - 12
Ground control vans - 3
Big "U" mounts - 12
24-ft rotor mods - 6
GRANDVIEW mods - 5
Day TV cameras - 12
Nite TV cameras - 12
Laser range finders - 10
Contrast trackers - 2
PPS-5 radars - 3
16-mm movie cameras - 6
BLOW LOW optics packages - 2
Hypervelocity guns - 10
Hypervelocity ammunition - 20,000 rounds
LARS - 16
SS-11 controls - 1
Vertical drop mods - 1
20-mm gun, SS-11, TOW, SHILLELAGH - Inventory
Hi-Rel electronics systems - 14
EGYPTIAN GOOSE I system - 1
EGYPTIAN GOOSE II system - 1
GRANDVIEW system - 3.

While this list identifies basic components and quantities, it does not identify models or modifications. As an example: there was only one Big "U" mount modified by North American Rockwell (now Rockwell International, Columbus Aircraft Division), incorporating direct drive torquers. During the program there were four versions of the Big "U" mount, yet the preceding list makes no indication of this.

According to data in the ARPA files the NITE GAZELLE assets were transferred to the Army in February 1972. The data on this transfer are incomplete in that they do not identify where the various serial numbered vehicles went or how they were configured. There is no mention of sensors, except day TV cameras, and no reference to weapon systems. Eight NITE GAZELLE vehicles with associated electronics including day TV cameras, two control vans, and two maintenance vans were provided to:

Army Electronics Command (TACOM)
Fort Monmouth, New Jersey
Attn: ECOM/AMSEL-CT-A
Mr. George Stech.

One NITE GAZELLE vehicle was provided to:

Army Security Agency
Electronic Sensor Laboratory (ESL)
Sunnyvale, California.

One control van and one maintenance van were provided to:

Army Aviation Command
St. Louis, Missouri.

Three NITE GAZELLE vehicles in various states of repair are at:

The Gyrodyne Company of America
St. James, Long Island, New York.

Additional vehicles, 100 QH-50C and 200 QH-50D (nonpurple plague free and not NITE GAZELLE configured) are stored in Arizona. These vehicles are under the control of:

Naval Air Systems Command
(NASC/Code 5104A)
Mr. Ed Forhmals.

The torquer driven Big "U" mount was returned to ASD. The Navy had a need for such a mount. Rockwell International, who made the torquer drive modification, knew of its location and availability, thus it was acquired for use on a Navy program.

The torquer driven Big "U" mount from the ARPA NITE GAZELLE Program has been successfully used on one Navy program and has been retrofitted and is ready for use on a second Navy program. The use of this mount not only

saved considerable expense but there was also a significant savings in calendar time(16).

The Navy ships are rather vulnerable to the STIX missile. The Navy needed to investigate the concept of using a laser-aided missile to counter this threat. Using the torque drive Big "U" mount and [illegible] optical equipment and a laser designator on a destroyer, tests were conducted off Point Mugu during the period March to June 1973. The project, known as HIP POCKET II, used the mount, laser designator, Hornet missile and drone aircraft from China Lake. It demonstrated that the destroyer under way can acquire, track, designate and kill the target (drone aircraft). This was the first attempt at using a laser aided system from a destroyer under way. Rockwell International, Columbus Aircraft Division, retrofitted the mount for shipboard use and built a new control console in 39 working days(16).

The second application of this mount is in support of tests at the Naval Weapons Laboratory. The mount was retrofitted by Rockwell International, Columbus Aircraft Division, in 8 weeks for this project. This project uses the mount to aim the laser designator for concept trials evaluating the use of laser guided projectiles. Checkout of the installed mount is in progress now (7 August 1974). Plans are to make use of it on this program for the next 6 months(16).

The Rockwell International project scientists indicated that it took considerable effort to locate the optical equipment that was used on this mount. Some of it was reacquired from the Army at Fort Monmouth and some from White Sands Missile Range(16).

<u>Reference List</u>

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(5) "Operational Evaluation of the QH-50D and Associated Telemetry Equipment (U)", Dept. of the Navy, Operational Test and Evaluation Force, Norfolk, VA, 423:ed. 3930 (O/SGO) Ser 066, February 12, 1968 [AD 388 129]. Confidential.

(6) "MACSA Artillery/Mortar/Rocket Countermeasure Study (U)", First Interim Report, I Reconnaissance and Location Aids, NACV TS 0001300567, MACV Office of Science Advisor, October 4, 1967. Top Secret.

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(14) "Test Schedule Report, AN/PPS-5 Radar Installation on QH-50 NITE PANTHER Vehicle, Flight Test Program (U)", Y70-325000-10 Rev. 4, Gyrodyne Company of America, Inc., St. James, Long Island, NY, December 18, 1968, Rev. 4 March 25, 1970. Confidential.

(15) "NITE GAZELLE Improved Optical Telescope Mount (U)", Final Report NR 72H-57, North American Rockwell-Columbus Division, Columbus, Ohio, January 17, 1972. Confidential.

(16) Information Obtained at Rockwell International, Columbus Aircraft Division, August 7, 1974.

(17) "Amendment B to A.O. 1283 for Design, Fabrication and Test of (a) Six One Mil Surveillance, Tracking and Weapon Mounts for the NITE GAZELLE Vehicles and (b) Six 24 Foot Rotor Systems (U)", Memorandum for the Director, Program Management, ARPA-ASO, Washington, DC, July 10, 1969. Confidential.

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(21) "Project Completion Report (U)", ARPA Order No. 1237, Naval Air Systems Command, AIR-53373E, Washington, DC, September 1970. Unclassified.

(22) "NITE GAZELLE Fire Control Computer/Tracker" (U), Final Report NR 71H-181, North American Rockwell, North American Aviation/ Columbus, Columbus, Ohio, May 14, 1971. Secret.

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APPENDIX

DESIGN INFORMATION ON THE MODIFIED QH-50D USED FOR NITE GAZELLE/PANTHER

APPENDIX

DESIGN INFORMATION ON THE MODIFIED QH-50D USED FOR NITE GAZELLE/PANTHER

The QH-50D remotely controlled helicopter was designed and built by Gyrodyne Company of America for the Naval Air Systems Command. This vehicle, Navy's DASH (Drone Antisubmarine Helicopter), was designed to operate off destroyer-class ships to permit standoff delivery of anti-submarine warfare, ASW, weapons. The Navy had modified some of their DASH vehicles in 1967 to provide remote surveillance vehicles to aid in fire control of Navy long range gun operations from ships in the Tonkin Gulf.

ARPA-ASO's NITE GAZELLE/NITE PANTHER Programs needed a remotely controlled aerial platform to carry its advanced sensor and sensor/weapon systems. The size, configuration, and performance of the QH-50D were well suited to ARPA needs and they were readily available on bail from the Navy.

The QH-50D is a coaxial helicopter powered by a Boeing Free Turbine engine. The airframe is unfaired and consists of castings which house the transmission and provide mounts for the engine, accessories, avionics equipment, and tubular undercarriage. The rotor system consists of two 20-ft-diameter, two-bladed, semirigid counter-rotating coaxial rotors. The vehicle has no tail. It uses movable tip brakes connected to both the upper and lower rotor blade tips to control yaw and provide positive directional control.

The three-view drawing, Figure A-1, shows the general arrangements of the vehicle in its original DASH configuration with a payload of two torpedoes. General vehicle data and selected dimensions are given in the Table A-1.

The DASH configured vehicle had a mission gross weight of 2327 lb compared to the NITE GAZELLE/NITE PANTHER mission gross weight of 2450 lb. Mission fuel weight for DASH was 348 lb and for NITE GAZELLE/NITE PANTHER it was as high as 806 lb. A new, increased capacity, self-sealing tank fuel system was incorporated into the modified QH-50D for NITE GAZELLE/NITE PANTHER. Some ARPA-ASO configurations of the vehicle were limited on fuel load; i.e., the maximum fuel load was less than tank capacity. This was necessary to provide additional weight allocation to the sensor or sensor/weapon system being carried. Table A-2 gives weight data and some performance data for the various configurations.

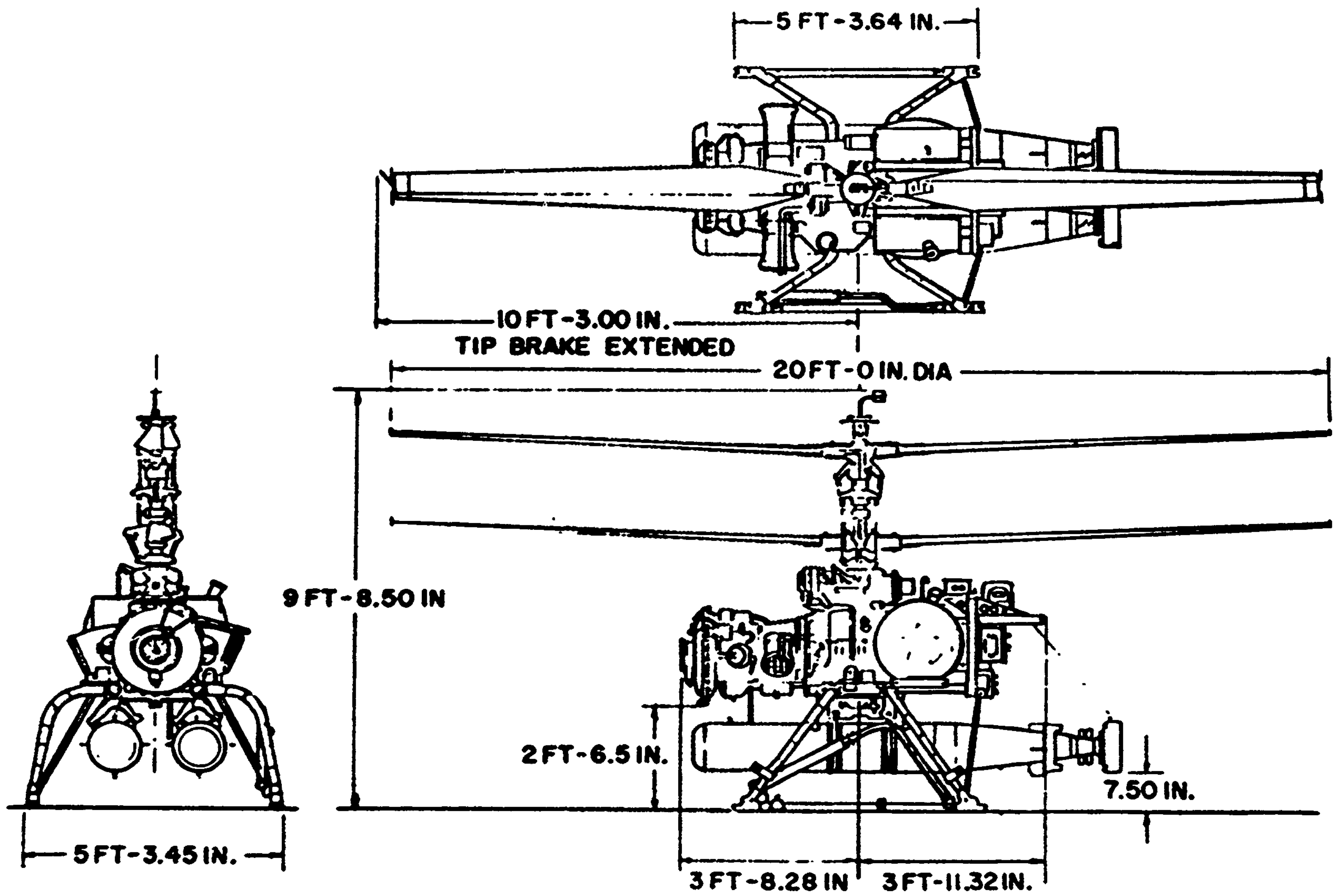

FIGURE A-1. THREE VIEWS OF QH-50D VEHICLE[A-1]

TABLE A-1. GENEPAL DATA AND SELECTED DIMENSIONS FOR THE QH-50D "DASH" VEHICLE[(A-1)]

Rotors	
Type	Coaxial Semirigid
Quantity	Two
Blades per rotor	Two
Rotor diameter	20 ft
Disc area	314.2 ft^2
Blade cord	
Root (theoretical)	13.00 in.
Tip (theoretical)	6.50 in.
Power Plant	
Boeing Free Turbine	Model T50-BO-12
Normal rated shaft horsepower	340
Military rated shaft horsepower	365
Dimensions	
Max length (rotors)	20 ft
Max height	9 ft 8.5 in.
Max width	5 ft 3 in.
Fuselage length	6 ft 8.28 in.
Skid length	5 ft 3.64 in.
Skid tread	5 ft 0 in.

TABLE A-2. WEIGHT AND PERFORMANCE DATA FOR QH-50D AND MODIFIED QH-50D VEHICLES[A-1,A-2]

	Configuration				
		NITE PANTHER I		NITE GAZELLE	
	DASH	Day	Night	Minimum Duration[(a)]	Maximum Duration[(b)]
Weight, lb					
Maximum gross	N/A	2450	2450	2450	2450
Mission gross	2327	2450	2450	2450	2411
Mission fuel (usable)	348	806[(c)]	768[(c)]	293	770
Sensor/weapons		109.3[(c)]	147.3[(c)]	1001	374
Performance					
Mission altitude, ft	S.L.	6000	6000	4000	4000
Mission airspeed, knots	80	60	60	60	60
Mission radius, nmi	47.2	41.8	41.8	22.0	105.0
Time on station, hr	0.6	1.9	1.7	0.5	0.5

(a) NITE GAZELLE - nite sensor package with laser target designator and LARS (BLOW HOLE II).

(b) NITE GAZELLE - day sensor package less laser target designator (no weapons complement).

(c) NITE PANTHER II values are 742 (806), 613 (768), 446 (109.3), and 601 (147.3).

The command and control system for the remotely controlled DASH vehicle consists of an airborne four-axis stabilization system and a receiver and decoder unit of the digital pulse control monitor (PCM) data link. Rotor rpm is maintained constant by the engine governor, a vertical gyro provides longitudinal and lateral stability, and a directional gyro provides yaw heading stability. The altitude axis incorporates a barometric altitude sensing device.

The command link has nine channels of on-off functions for weapon arming, engine stopping, release of landing cable, and other functions where required. A feature of the remote control system is the memory function. It allows the drone to operate for an indefinite period using the last received command data. The loss of a radio signal actuates the carrier loss function which places the drone in a hover condition at the last commanded altitude and heading. There are four proportional command channels.

The original operational DASH vehicles deployed by the Navy did not carry a telemtry system to provide the controller with vehicle status data. However, the vehicles used for crew training did carry a telemetry system to provide 14 parameters of vehicle status data to the instructor (and student controller?). This support system was known as SUP-TEL.

An improved telemetry system was installed in a NITE GAZELLE/NITE PANTHER vehicle after the SEA NITE PANTHER Program. This system, krown as OP-TEL, Operational Telemetry, provided 38 parameters of data. The parameters monitored on the various flight test configured vehicles varied according to the sensor or sensor/weapon system needs. Actually the 38-parameter capability is insufficient for the modified QH-50D vehicle with many of the sensor/weapon system payloads. The Navy OPTEVFOR Report[A-4] shows only three weapon functions monitored for the DASH configured QH-50D. All other parameters (35) monitored are airframe, propulsion, and navigation data. On some tests, BLOW LOW, for example, propulsion and navigation parameters were relinquished to permit monitoring of seven sensor/weapon system parameters[A-5].

NITE GAZELLE/NITE PANTHER sensor and sensor weapon system payloads were generally supported from one- or two-axis gimbal mounts which hung down from the center of the vehicle between the two landing skids. The exceptions to this are the bomblet dispenser and the final LARS II launch tube which were mounted on the side of the vehicle. The bomblet dispensers were rigidly mounted while the LARS II launch tube mount moved in pitch only[A-6].

The 24-ft rotor system for the QH-50D-2 provides increased lift without a major change to the basic QH-50D system. The increased rotor diameter required a change in the drive gear train to reduce rotor rpm to keep tip speed unchanged. Basic vehicle weight only increased 40 lb; however, maximum gross weight increased 300 lb, permitting the added weight for fuel or sensors or a combination of both. The main interest was in added fuel for longer mission time.

Appendix References

(A-1) "ARPA Project NITE PANTHER Descriptive Report (U)", Gyrodyne Company of America, Inc., St. James, NY, May 20, 1968. Unclassified.

(A-2) "Some Physical and Operational Characteristics of the QH-50 Drone Helicopter (U)", D-16929-ARPA, Rand Corporation, Santa Monica, CA, November 20, 1969. Confidential.

(A-3) "Remotely Piloted Coaxial Helicopter Vehicle (U)", Gyrodyne Company of America, Inc., St. James, Long Island, NY (No date, no document number). Confidential.

(A-4) "Operational Evaluation of the QH-50D and Associated Telemetry Equipment (U)", Dept. of the Navy, Operational Test and Evaluation Force, Norfolk, VA, 423:ed. 3930 (0/S60), Ser 066, February 12, 1968 [AD 388 129]. Confidential.

(A-5) "Project BLOW LOW Final Report (U)", RML Technical Memorandum No. 344, ET72-15520, Range Measurements Laboratory, Patrick Air Force Base, FLA, September 24, 1973. Secret.

(A-6) "Advanced Standoff Interdiction Weapon and Sensor System (U)", RCA Service Co., Patrick AFB, FLA, June 15, 1972. Confidential.

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